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Geotechnical investigation and testing — Laboratory testing of soil —

Part 9: **Consolidated triaxial compression tests on water saturated soils**

Reconnaissance et essais géotechniques — Essais de laboratoire sur les sols —

Partie 9: Essais en compression à l'appareil triaxial consolidés sur sols saturés

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 341, *Geotechnical investigation and testing*, in collaboration with ISO Technical Committee TC 182, *Geotechnics*, in accordance with the agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 17892-9 cancels and replaces ISO/TS 17892-9:2004, which has been technically revised. It also incorporates ISO/TS 17892-9:2004/Cor.1:2006.

A list of all the parts in the ISO 17892 series can be found on the ISO website.

Introduction

This document covers areas in the international field of geotechnical engineering never previously standardised. It is intended that this document presents broad good practice throughout the world and significant differences with national documents is not anticipated. It is based on international practice (see Reference [1]).

Geotechnical investigation and testing — Laboratory testing of soil —

Part 9: Consolidated triaxial compression tests on water saturated soils

1 Scope

This document specifies a method for consolidated triaxial compression tests on water-saturated soils.

This document is applicable to the laboratory determination of triaxial shear strength under compression loading within the scope of geotechnical investigations.

The cylindrical specimen, which can comprise undisturbed, re-compacted, remoulded or reconstituted soil, is subjected to an isotropic or an anisotropic stress under drained conditions and thereafter is sheared under undrained or drained conditions. The test allows the determination of shear strength, stress-strain relationships and effective stress paths. All stresses and strains are denoted as positive numerical values in compression.

NOTE 1 This document provides a test for a single specimen. A set of at least three relatable tests are required to determine the shear strength parameters from these tests. Procedures for evaluating the results are included in Annex B and, where required, the shear strength parameters are to be included in the report.

Special procedures such as:

a) tests with lubricated ends;

b) multi-stage tests;

c) tests with zero lateral strain (K_0) consolidation;

d) tests with local measurement of strain or local measurement of pore pressure;

e) tests without rubber membranes;

f) extension tests;

g) shearing where cell pressure varies,

are not fully covered in this procedure. However, these specific tests can refer to general procedures described in this document.

NOTE 2 This document fulfils the requirements of consolidated triaxial compression tests for geotechnical investigation and testing in accordance with EN 1997-1 and EN 1997-2.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14688-1, *Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description*

ISO 17892-1, *Geotechnical investigation and testing — Laboratory testing of soil — Part 1: Determination of water content*

ISO 17892-2, *Geotechnical investigation and testing — Laboratory testing of soil — Part 2: Determination of bulk density*

ISO 17892-3, *Geotechnical investigation and testing — Laboratory testing of soil — Part 3: Determination of particle density*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
CIU-test
isotropically consolidated undrained test

3.2
CAU-test
anisotropically consolidated undrained test

3.3
CID-test
isotropically consolidated drained test

3.4
CAD-test
anisotropically consolidated drained test

3.5
pore pressure
pressure of water in the void space within the soil specimen

3.6
back pressure
external pressure by which the pore pressure is increased prior to consolidation or shearing to ensure saturation

3.7
cell pressure
pressure applied to the cell fluid

3.8
deviator stress
difference between the vertical total stress and the horizontal total stress

3.9
effective stress
difference between the total stress and pore pressure

3.10
failure
stress or strain condition at which one of the following criteria are met:

— peak deviator stress

— peak effective stress ratio i.e. the ratio between the vertical and horizontal effective stress

— a specified deformation criterion e.g. 10 % vertical strain

— other definitions if required

4 Symbols

$\mathrm{A_i}$	initial cross sectional area of the specimen
A_{cor}	cross-sectional area of the specimen at any point in time
a	cross-sectional area of the piston if an external load cell is used
B	pore pressure coefficient i.e. the ratio of the increase in pore pressure, Δu resulting from an increment of cell pressure, $\Delta\sigma_c$ under undrained conditions
D_c	specimen diameter at the end of consolidation
D_i	initial specimen diameter
D_m	initial internal diameter of the confining membrane (before it is placed on specimen)
E_m	elastic modulus of the confining membrane
F	factor for calculating the rate of displacement of the load frame
f	factor relating the vertical strain to the specimen volumetric strain
H_c	specimen height at the end of consolidation
H_i	initial height of specimen
h	distance from the top of the top cap to the mid-height of the specimen
K_{fp}	load (when fully mobilized) carried by filter paper covering a unit length of the specimen perimeter
P	vertical load reading
P_{fp}	fraction of perimeter covered by filter paper
t_m	initial thickness of the unstressed membrane
t_{50}	time required for 50 % primary consolidation to take place
t_{100}	time required for 100 % primary consolidation to take place
u	pore pressure at the mid height of the specimen
u_B	back pressure (i.e. the pore pressure at start of shearing)
V_i	initial volume of specimen
v_{max}	rate of vertical displacement of the load frame during shearing
W	gravity force acting on the sum of the deadweight hanger (if used), the piston, the top cap and one half of the soil specimen
ΔH	specimen change in height (with compression being a positive numerical value)

ΔH_c	vertical change in height during consolidation, including any vertical change in height during saturation, if measured
Δu	change in pore pressure at the mid height of the specimen
ΔV	specimen volume change (with a reduction in volume being a positive numerical value)
ΔV_c	volume change up to the end of consolidation
$\Delta \sigma_c$	change in cell pressure
$(\Delta \sigma_h)_m$	correction to horizontal total stress due to membrane restraint
$(\Delta \sigma_v)_{fp}$	correction to vertical total stress due to restraint of the filter paper
$(\Delta \sigma_v)_m$	correction to vertical total stress due to membrane restraint
γ	unit weight of the cell fluid
ε	strain (with compression being a positive numerical value)
ε_{sv}	vertical strain during shear (expressed as a ratio)
ε_{svol}	volumetric strain during shear (expressed as a ratio)
ε_v	vertical strain (expressed as a ratio)
ε_{vf}	expected vertical strain at failure (expressed as a ratio)
$(\varepsilon_v)_m$	vertical strain of the membrane (expressed as a ratio)
ε_{vol}	volumetric strain
$(\varepsilon_{vol})_m$	volumetric strain of the volume enclosed by the membrane (expressed as a ratio)
σ_c	cell pressure
σ_h	horizontal total stress at the mid height of the specimen (see note)
σ'_h	horizontal effective stress at the mid height of the specimen (see note)
σ'_{hc}	horizontal effective stress at the mid height of the specimen at the end of consolidation
σ_v	vertical total stress at the mid height of the specimen (see note)
σ'_v	vertical effective stress at the mid height of the specimen (see note)
$\sigma_v - \sigma_h$	deviator stress
$(\sigma'_v - 2\sigma'_h)/3$	mean effective stress
σ'_{vc}	vertical effective stress at the mid height of the specimen at the end of consolidation

NOTE Throughout this document, effective stresses are indicated by a prime. Vertical and horizontal directions are indicated by the suffixes "v" and "h" respectively. This convention ensures that the directions of the action of stress acting on the specimen are clear and independent of their relative magnitudes.

5 Apparatus

5.1 General

The equipment shall undergo regular calibration, maintenance and checks as specified in Annex A.

A schematic diagram of a typical apparatus for triaxial compression testing is shown in Figure 1.

